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Review

A review of alternative approaches in the management of iatrogenic femoral pseudoaneurysms

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The management of iatrogenic pseudoaneurysms (IPAs) demands close co-operation between radiologist, vascular surgeon and plastic surgeon. Ideally, each patient should be reviewed employing a team approach. Many IPAs require only observation; those with a volume greater than 6 cm^3 will require treatment as spontaneous thrombosis is uncommon. Radiological treatment options include ultrasound guided compression repair (UGCR), embolisation, and covered stenting. Occasionally, these are unsuccessful or contra-indicated, and the vascular surgical approach is discussed in detail. Finally, the role of the plastic surgeon in dealing with skin ischaemia is detailed.

Key words: Pseudoaneurysms – Femoral – Catheterisation, Complications – Embolisation – Stents – Ultrasound

The majority of IPAs occur in the common and superficial femoral arteries following percutaneous puncture, particularly cardiac catheterisation. A minority of cases of IPA are due to needle biopsies and parenteral injections.[1] Now that their natural history is better understood,[2] there has been a significant alteration in management away from early surgical repair towards colour Doppler ultrasound (CD U/S) monitoring and UGCR,[3,4] or other minimally invasive radiological techniques, such as embolisation or endoluminal stent grafting. In our opinion, the management of IPA is best approached using a combination of three disciplines: radiology, vascular surgery and plastic surgery. Vascular surgeons are involved when radiological techniques fail, the patient is unstable, or in the presence of a mycotic aneurysm. The plastic surgeon's role is in the management of skin necrosis.

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Table 1 Risk factors for iatrogenic pseudoaneurysm formation[6–17]

Large size (8–12F) sheaths
Simultaneous artery and vein catheterisation
Faulty puncture technique
Brief manual compression
Anticoagulation
Difficult-to-compress sites
Obesity
Penetrating trauma including surgery
Heavily calcified arteries
Antegrade catheterisation
Arterial hypertension
Haemodialysis

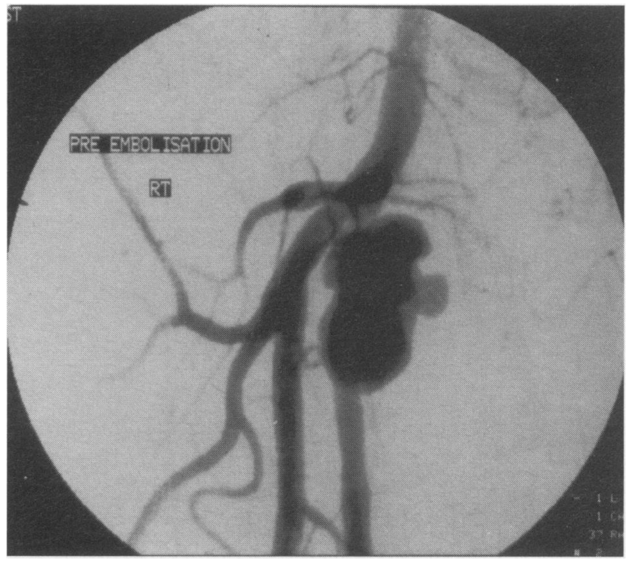

Figure 1 A multi-lobed iatrogenic pseudoaneurysm (IPA) is seen arising from the superficial femoral artery (SFA).

Incidence

The incidence of IPA has been reported to lie between 0.7% and 20%[3] following interventional cardiac procedures; the risk factors are well defined (Table 1). Older studies underestimated the incidence of the problem, relying largely on clinical examination and retrospective data, but more recent prospective work using CD U/S has given better insight into the true extent of the problem.[5] Katsenschlager *et al*[5] insonated 581 puncture sites in 565 patients for peripheral vascular disease who had undergone diagnostic and therapeutic angiography and found an overall incidence of IPA of 7.7%. Not surprisingly, 77% of these involved patients anticoagulated with heparin following sheath removal, and 83% involved interventional catheter procedures. Almost certainly, there has been an increase in the incidence of IPAs and this is largely related to the wide variety of aggressive cardiological and peripheral vascular interventional work that is now taking place. These procedures involve large (8–12F) sheaths, simultaneous catheterisation of both artery and vein, brief manual compression and the extensive use of both anticoagulation and thrombolysis.[6–17]

Natural history

The natural history of IPAs in the common femoral artery (CFA) has been evaluated using CD U/S.[5,18] The risk of rupture is related primarily to the size of the pseudoaneurysm sac, but is also related to anticoagulation.[2,19,22] For femoral pseudoaneurysms, a volume of greater than 6 cm^3 (approximately 1.8 cm in diameter) merits treatment as spontaneous thrombosis is uncommon.[18] Certainly, continued anticoagulation – often due to a cardiac indication – diminishes the likelihood of an IPA undergoing spontaneous thrombosis, and the natural history in this situation is unpredictable.[2,23] Some authors have suggested the age and size of the lesion and the length and width of the track are predictive variables in these situations.[24–26] The formation of multiple lobules (Fig. 1) has been attributed to the natural evolution of simple pseudoaneurysms when they are subjected to continuous increased arterial pressure; it is a way of diminishing intraluminal pressure in a pseudoaneurysm according to Laplace's law.[24]

The majority of IPAs are asymptomatic, but described long-term sequelae include progressive enlargement, compression neuropathy, haemorrhage, rupture, pain, infection, distal embolisation, deep venous thrombosis and pulmonary embolus.[4,27] Delayed rupture following successful UGCR has recently been described[28] for the first time, but must be very rare.

Imaging pseudoaneurysms

CD U/S is the best modality for imaging IPAs in the CFA and SFA, easily distinguishing them from haematoma or arteriovenous fistulae, and will give precise anatomical information, as well as the velocities within the sac and the neck.[19,29,30] In less accessible areas of the body, CD U/S is less useful and contrast enhanced computed tomography (CECT), particularly with spiral acquisition and 3-D reformatting, can provide excellent anatomical information. Digital subtraction angiography (DSA) is

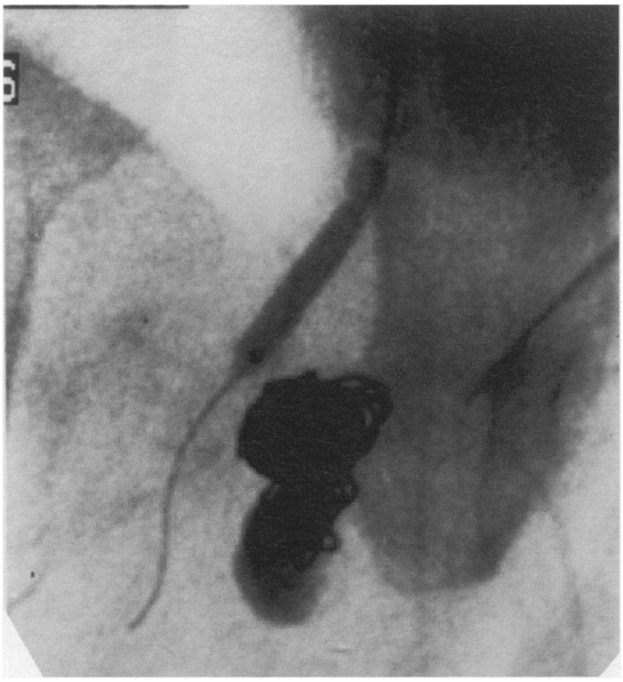

Figure 2 An angioplasty balloon is inflated across the neck of the pseudoaneurysm while the sac is filled with coils following direct puncture.

only required prior to endovascular intervention or occasionally surgery (Fig. 4). Magnetic resonace angiography (MRA) is starting to feature as a viable alternative to DSA, but its usefulness in relation to IPAs has yet to be defined.

Radiological management

UGCR is the first line treatment for femoral IPAs.[4,25,31,32] There are, however, a number of contra-indications to this technique; these include inaccessible site, limb ischaemia, infection, large haematomas with overlying skin ischaemia, compartment syndrome and prosthetic grafts.[4] UGCR has been shown to be less successful in patients with large IPAs, in patients who are anticoagulated and in patients who cannot tolerate the associated discomfort.[3,4]

The basis behind the technique of UGCR lies in identifying the neck of the IPA at the point where it communicates with the native artery. Compression is then applied using the US to accurately guide the direction of compression. The force should be sufficient to cause cessation of colour flow within the IPA while not compromising the flow in the native artery. If this is not possible, then the technique should be abandoned as femoral artery thrombosis has been reported.[4] Compression needs to be applied until sac thrombosis occurs, and this averages about 45 min; operator fatigue and patient intolerance are limiting factors. Anticoagulation is itself a risk factor for IPA formation, and these patients will often have large haematomas, and very long periods of compression may be required. The use of two operators and a mechanical C arm compression device has been described,[33,34] but a recent innovation using a Femostop™ (RADI Medical Systems AB) device filled with saline to act as a sonic window for the ultrasound probe offers great promise.[35] The significance of this recent improvement is that the operator does not physically compress the IPA for the entire duration as the Femostop™ accomplishes this, and yet the precise position of compression can be regularly checked to ensure that it is satisfactory. Similarly, measuring the oxygen saturation of the hallux may be useful to ensure distal arterial flow is not compromised.

The overall success rate in UGCR has been reported to lie between 71% and 90% for femoral IPAs.[3,4] The size of the lesion is the greatest determinant of success; those with any dimension greater than 4 cm were least successful in one study.[3] The success rate is significantly improved if judicious sedation and analgesia is employed.[4]

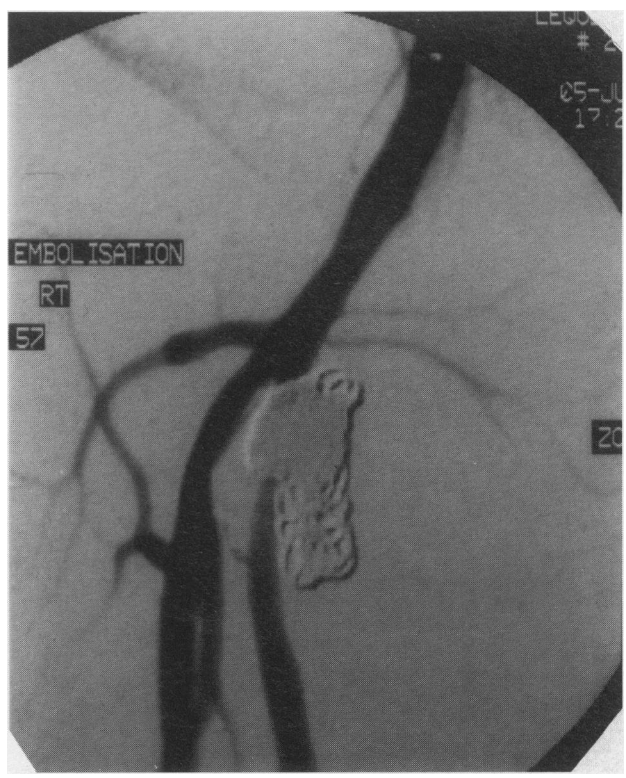

Figure 3 Completion angiogram demonstrating occlusion of the IPA, but normal flow down the SFA and PFA.

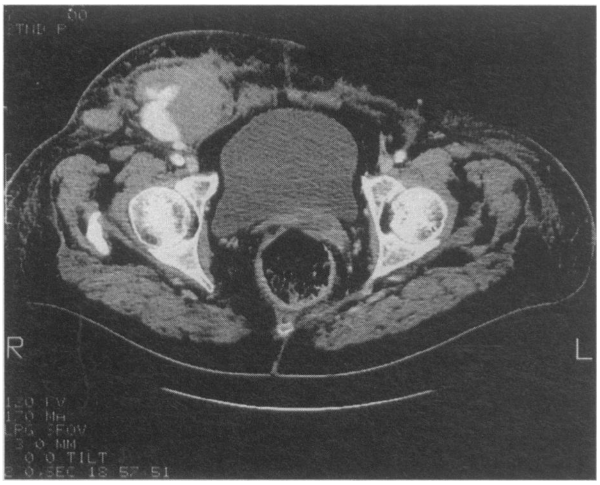

Figure 4 A CECT demonstrates the origin of the pseudoaneurysm arising from the anterior aspect of the right common femoral artery.

Endovascular management

IPAs may be excluded by embolisation,[36–45] with a perfusion balloon,[46] and by placement of covered stents/ endoluminal prostheses (EP).[46–56] On rare occasions, uncovered stents may be used in conjunction with embolic agents in aneurysms with wide necks to prevent embolic material leaving the sac.

Embolisation of IPAs has been carried out with a variety of agents including coils, thrombin and cyanoacrylate.[36–45] The IPAs can be accessed via the neck or by direct puncture (Figs 1–3). Various techniques of direct puncture have been described including the placement of an angioplasty balloon across the neck reducing inflow and aiding haemostasis in the event of sac rupture. In a similar fashion IPAs can be temporarily excluded using a perfusion balloon; blood flows through a central channel at a rate sufficient to keep the limb perfused, while the neck of the IPA is excluded from the circulation.[46]

Both coils and thrombin can be injected percutaneously into IPAs; the advantage of the latter is that it only requires a fine needle puncture. In the second technique, the parent artery can be embolised distal and then proximal to the IPA; some authors have recommended packing the sac in addition to proximal and distal occlusion.

Indications for covered stents include: aneurysms that cannot be accessed via their necks or by direct puncture or where the overlying haematoma is to be surgically evacuated. The contra-indications for these prostheses are detailed in Table 2. The majority of these prostheses reported in the literature have been used for the exclusion of atherosclerotic aneurysms; however pseudoaneurysms have been treated in this manner.[15,41,46–56]

EPs are available commercially or can be made on an individual basis. They must be placed across the neck of the IPA to exclude inflow to the sac (Figs 4–7). Any vessels which might backfill the sac should be embolised prior to placement of the EP. For example, with IPAs of the iliac system, the internal iliacs must be embolised or the sac will fill by crossover flow leading to continued expansion of the sac and possible rupture.[46,55] CD U/S or spiral CECT should be used to ensure sac thrombosis; continued filling should be regarded as treatment failure and the risk of rupture is not reduced.

Not all IPAs can be treated by embolisation and the contra-indications are listed in Table 3.

Table 2 Contraindications to the use of endoluminal prostheses in the management of IPAs

Infection
Site of flexion
Small (less than 7 mm) arteries

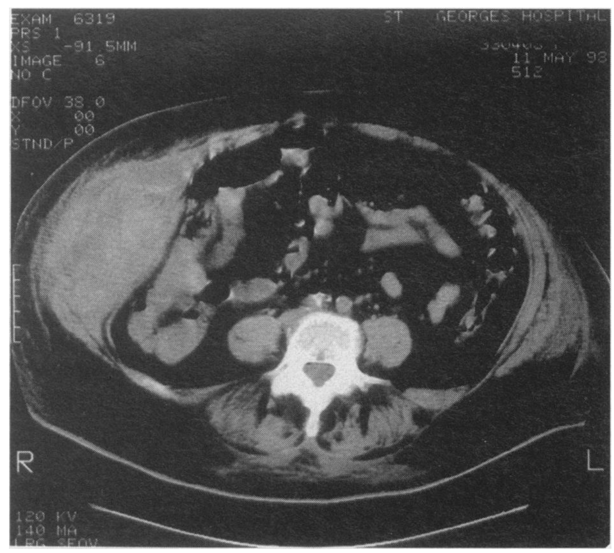

Figure 5 The same study at a level approximately 20 cm cephalad to the level of Figure 4. Note how far superiorly the haematoma extends. This haematoma will have to be evacuated and skin grafting considered. Hence both UGCR and embolisation are contraindicated, the former as further skin pressure would be detrimental; and the latter as removing the haematoma will mean there is no support for the coils to remain in place.

Figure 6 A DSA obtained to delineate the exact anatomy.

Vascular surgical management of femoral pseudoaneurysms

It is unfortunate that most pseudoaneurysms occur in patients least tolerant of general anaesthesia, vascular reconstruction and the associated blood loss. For that reason, treatment by UGCR or percutaneous embolisation is an attractive option and probably the first choice in many hospitals. However, there are situations when surgical treatment is mandatory:

1. There is rapid expansion of the IPA, and there may not be time to wait for less invasive treatments.
2. There is concomitant distal ischaemia or neurological deficit due to local pressure from the IPA, or distal embolisation from within it.
3. The IPA is infected ('mycotic'). The natural history is then one of rapid enlargement with subsequent rupture or septic emboli, endangering both life and limb. Embolisation with foreign bodies will only increase infection and is contra-indicated.
4. Percutaneous treatment has failed.
5. Compromised soft tissue viability.

The surgical approach often depends on whether the IPA is infected. Although a transient bacteraemia occurs in 4% of patients undergoing arterial catheterisation,[57] the vast majority of postangiography IPAs are sterile; but if there is clinical suspicion of infection, for example rigors, pyrexia, local erythema or pus, leucocytosis and a high ESR then appropriate cultures should be done.

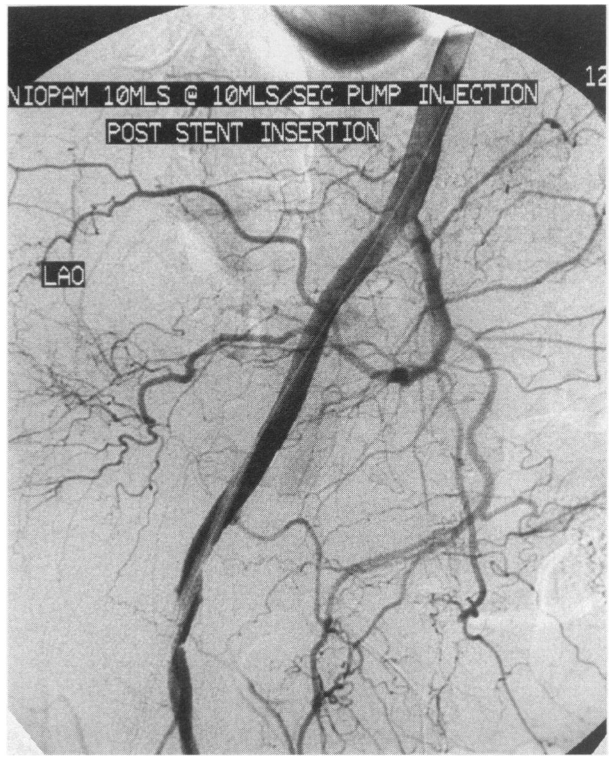

Figure 7 Post treatment image demonstrates satisfactory exclusion following insertion of an endoluminal prosthesis. In fact the skin healed without skin grafting following removal of the haematoma.

Table 3 Contraindications to embolisation of IPAs

Infection
Uncontrolled outflow (liquid agents)
Essential parent artery

Non-infected pseudoaneurysm

The conventional approach is to gain proximal and distal control of the IPA, open the fibrous pseudocapsule and evacuate the haematoma. The puncture site is identified and one or two sutures of a synthetic, non-absorbable suture placed transversely to avoid narrowing. If the vessel is severely damaged or diseased, formal arteriotomy with endarterectomy and vein patch angioplasty may be required with systemic heparinisation. With experience, the technique may be accelerated to simply incising the sac and evacuating the pulsatile clot. The subsequent brisk arterial bleeding can be controlled by either digital pressure over either the puncture site or the vessel proximally, or by introducing a 3Fr catheter through the arterial hole and inflating the balloon.[58] This 'blind' technique is especially useful where the anatomy of the area and feeding vessels is distorted and there are important neighbouring structures, *e.g.* complex carotid or subclavian pseudoaneurysms.[59] Radiological balloon occlusion can assist the surgeon by providing haemostasis and allowing the traumatised artery to be accessed through the sac.

Infected pseudoaneurysm

The goals of surgical management here are the eradication of infection and maintenance of distal perfusion. The former is achieved using high doses of intravenous antibiotics based on pre-operative blood cultures or peroperative tissue culture, together with excision of the infected aneurysm sac. The most commonly isolated bacteria are *Staphylococcus aureus* and *Salmonella* species. Since bacteraemia may persist following surgery, antibiotics should continue for at least 6 weeks.

Simple ligation of infected femoral IPAs is associated with a 30% amputation rate with a further 25% suffering incapacitating leg ischaemia.[60] It is, therefore, desirable to perform primary bypass wherever possible prior to excision of the aneurysm. Synthetic grafts should be avoided and autogenous vein bypasses should run through remote and healthy tissue such as the obturator canal or the transperineal route.[60]

Management and plastic surgery

The opinion of a plastic surgeon should be sought if the skin overlying the pseudoaneurysm is at risk of necrosis. Although UGCR may control expanding haematomas, this external pressure may further compromise skin viability; therefore, the joint team approach is vital at an early stage as these are usually poor risk patients who are often anticoagulated, have cardiac problems and in whom morbidity and mortality is high.

A management plan should be devised and discussed with the patient and the other teams involved with care of the patient, so that timing of surgery, planning of incisions, anticoagulation regimens, type of anaesthetic and other aspects of care can be worked out.

The critical factor is determining the viability of the overlying skin. This may range from: (a) clearly viable – in which case a watch and wait policy may be instituted with daily review of the patient by the plastic team; (b) suspect viability; (c) expanding haematoma which will need early decompression with or without skin cover.

A careful wait and watch policy can be followed if there is ecchymosis overlying the pseudoaneurysm with no breach of the skin. If skin viability is suspect decompression of the frequently co-existent haematoma,[66] debridement of non viable and any infected tissue with or without pseudoaneurysm repair should be carried out. If at all possible, any infected foreign material, such as a prosthetic vascular graft, should be removed and an alternate vascular reconstruction performed through healthy tissue. However, in some situations, excision of the wound and reconstruction with a muscle flap[61–65] with long term antibiotic cover can be of value.[67]

Reconstruction of the wound depends on the extent, availability and blood supply of local tissue. Options for cover include direct closure which, if not possible immediately, may become possible after wound contraction after a period of vacuum assisted suction dressings. For larger defects, skin grafting is an option. This requires a viable bed and is acceptable in emergent situations even if the femoral vessels are exposed. This alone, however, provides minimal durable coverage.[61]

Muscle flaps provide secure cover for the underlying groin vessels and the choice of muscle flap depends on whether the femoral artery or the external iliac artery is perfused. The sartorius, gracilis, vastus lateralis, rectus femoris and tensor fasciae latae muscle flaps are supplied by the femoral artery via the medial and lateral circumflex branches. The rectus abdominis muscle is supplied by the external iliac artery via the deep internal epigastric artery and the internal oblique muscle via the deep circumflex iliac artery branch.

A single stage reconstruction with minimal defects to the donor site at an **early stage** leads to necessary early rehabilitation of these often ill and debilitated patients.

Cost comparison between the various treatment alternatives

Cost comparisons of UGCR, percutaneous embolisation, endovascular stenting and surgery will vary between hospitals, but in our institution the relative costs per patient are of the order of UGCR £500, percutaneous balloon perfusion catheter £1000; percutaneous coiling £1800, endoluminal exclusion by covered stenting £2200, and vascular surgery £3000–£4000. These figures take into account the time of the procedure, physician time, theatre or radiology suite time, disposables (including coils or stents) and average hospital stay. Such comparison is of limited value, as the techniques are complementary; and patients on whom surgery is performed are, generally, more complicated and unstable.

Conclusions

Most iatrogenic pseudoaneurysms arise from the common or superficial femoral artery, and most will respond well to ultrasound guided compression repair. In patients in whom this fails or is contra-indicated, then a team approach should be adopted. If there are no contra-indications, then the patient should be admitted under the vascular surgeons and percutaneous endovascular exclusion attempted. If this is unsuccessful, or should there be signs of infection or rapid expansion, surgery is preferable. If skin or soft tissue cover is at risk, plastic surgical advice should be sought. Prospective advice on incisions may be helpful to avoid further compromise.

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Cover picture

The multiformity of lancets

Characterised by its pointed lance shape, the thumb or bleeding lancet (French, *lancetter*; Latin, *lancea*) is a 16th century innovation, replacing the fleam for venesection. Pare (1564) and Botallo (1577) illustrated both lancet and fleam, the latter soon disappearing from human, but not veterinary, practice. Probably the lancet with mobile protective leaves evolved in Italy. Hippocrates and others referred to phlebotomes which from scanty archaeological evidence were arrow shaped knives employed for a variety of procedures.

Steel lancet blades were symmetrical, sharpened only at the tip and guarded by scales or leaves of horn, tortoise shell, ivory, mother-of-pearl (Fig. 1) and, at their demise in the late 19th century, of nickel plated steel. They were kept in small cases for the waist-coat pocket and hence instantly available at all times; the College has a silver case which allegedly, was incarcerated with its owner in the Black Hole of Calcutta.

After folding back the leaves, the blade was grasped between thumb and index, and veins were nicked in line or obliquely to create a small wound and swift discharge of blood. A mainstay of medical treatment for centuries, its hazards included arterial bleeding, nerve injuries, infection, arterio-venous fistulae and death: William Tully (1823) concluded: 'The bleeding lancet is a minute instrument of mighty mischief'.

Attempts to remedy defects produced the spring lancet in Austria (Fig. 3) whereby the depth of incision was regulated mechanically, the blade striking at a right angle, to imitate the fleam; even so this required considerable expertise. It entered German, Dutch and parts of American practice, whereas the thumb lancet persisted in Italy, France and Britain; all subscribed to the alternative of leeches. Curiously, a venepuncture needle failed to emerge until the late 19th century.

Gum lancets (Fig. 4) also resembled the ancient fleam and were devised to scarify the gums of teething infants, although some surgeons favoured their finger nails. The seton needle (Fig. 2) is also confusing, having a lance shaped double blade. However this is removable from its leaves and has a rectangular aperture for carrying silk or other threads which were inserted to form a seton or elective discharging wound, as a method of counter irritation.

Enlarged thumb lancets were termed abscess lancets and very enlarged forms termed lithotomes for bladder stone extraction *per perineum*. John Hunter favoured a thumb lancet for removing embedded foreign bodies from the eye and Jenner for vaccination. Later, its blade was diminished to a spear shape with a central groove to convey serum, forming one of the several forms of vaccination lancet.

John Kirkup
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Key to lancets, from bottom left clockwise:

Figure 1 Thumb lancet with mother-of-pearl leaves opened, maker Weiss, *circa* 1820.

Figure 2 Seton needle removed form protective leaves; note rectangular aperture, maker Wood, *circa* 1830.

Figure 3 Spring lancet, mechanism in brass box, release lever visible, blade in discharged position, maker unknown, *circa* 1800.

Figure 4 Folding gum lancet, ivory handle, in locked open position, maker Wood, *circa* 1850.